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Seroprevalence of porcine cysticercosis in traditional farms in South-Eastern Côte d'Ivoire

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ABSTRACT

Background: Porcine cysticercosis is an endemic parasitic zoonosis in many developing countries. The objective of this study was to estimate the seroprevalence of porcine cysticercosis in traditional pig farms in the departments of Dabou, Aboisso and Agboville.
Methods: Blood samples were taken from pigs and analyzed by ELISA (IgG) and western blot. Data on farming practices and pig characteristics were collected. Multivariate logistic regression models were constructed to identify risk factors.
Results: A total of 668 pigs were sampled from 116 farms and 639 samples were analyzed. The seroprevalence of cysticercosis was estimated at 13.2%. Overweight [OR = 2.6; 95%CI (1.3–4.9)] and fat pigs [OR = 2.3; 95%CI (1.0–4.8)] were twice as likely to be seropositive for cysticercosis. This risk was increased in farms using well water for drinking [OR = 2.5; 95%CI (1.0–6.3)] as well as those reporting veterinary care of the animals (OR = 2.9; 95%CI (1.2–7.3)).
Conclusions: This study demonstrated the circulation of *Taenia solium* in pig farms in southern Côte d'Ivoire.

1. Background

Porcine cysticercosis is a larval cestodosis caused by *Taenia solium*. It is linked to the ingestion by pigs of eggs of the parasite present in food or water contaminated by human feces. Humans are the definitive host in the biological cycle, and accidentally, the intermediate host such as pigs.

With the exception of regions where the breeding and the consumption of pigs is a religious taboo, porcine cysticercosis probably affects all countries south of the Sahara where the conditions for the persistence of this zoonosis are generally met: poor hygiene and sanitation conditions, rural areas with permanent or seasonal pig roaming and lack of inspection of pig meat (Preux, 1996). This

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disease has also economic and public health impacts in these areas (Geerts, 1995). However, in pigs, the disease is most often subclinical, whereas in humans, cysticercosis induces polymorphic signs dominated by epilepsy (Carpio et al., 1998).

In Côte d'Ivoire, very few data are available concerning porcine cysticercosis. When available, they are mostly pretty old. However, pork meat is widely consumed in Côte d'Ivoire and mainly provided by local pig farms rearing a total of 411,520 heads. They include 121,520 (30%) of modern pigs and 290,000 (70%) of local breed. Among them only 6.8% of modern pigs are slaughtered under veterinary control. Indeed, >93% of carcass are thus not subject to any veterinary control, in particular those from traditional breeding (Mirah/dpsp, 2017). Most of the animals are bred for a short time (6–8 months) to stray and are slaughtered during festivities out of

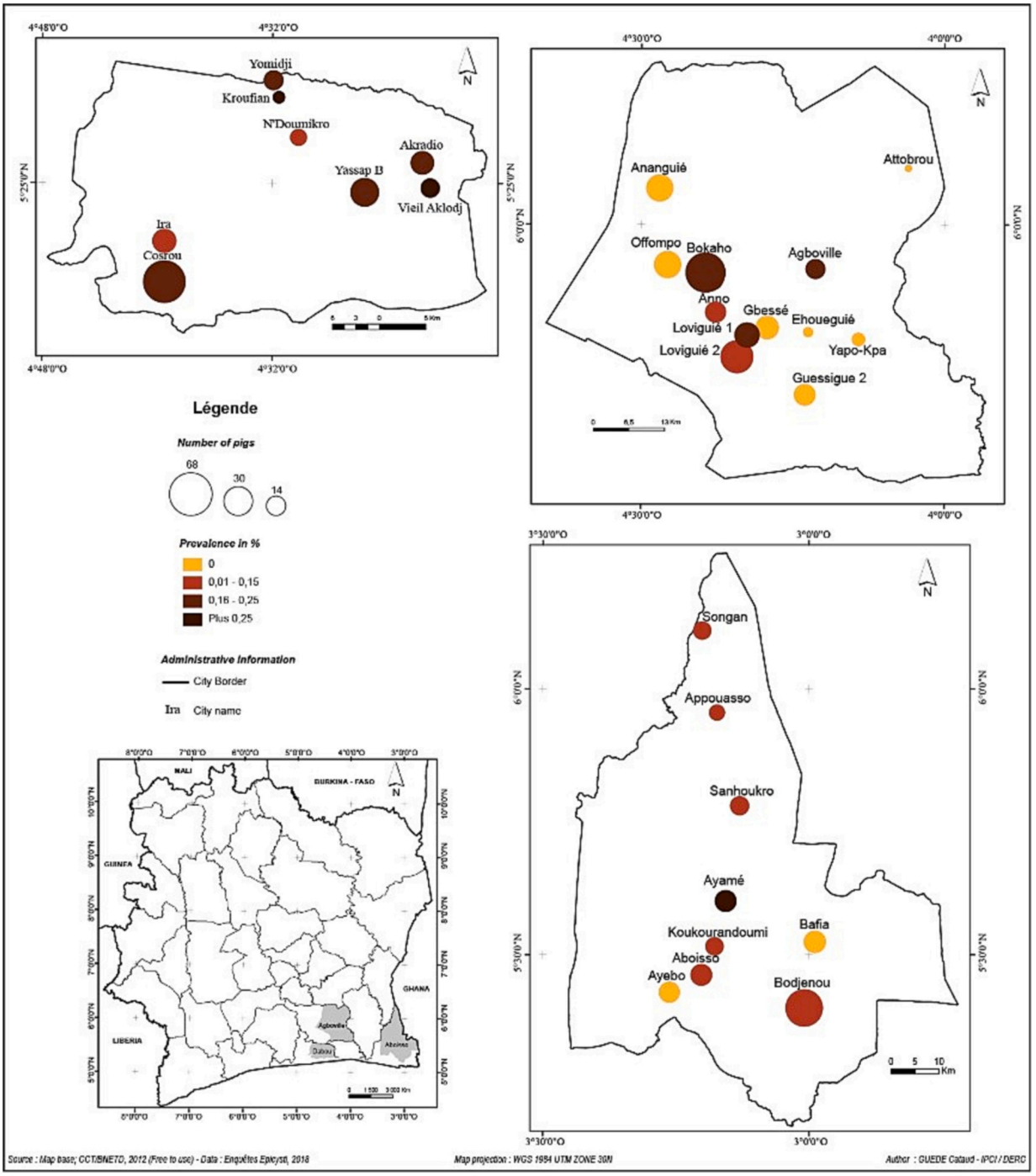

Fig. 1. Geographical distribution of farms included in the study.

abattoir and thus without veterinary control.

Indeed, in 1978 in Côte d'Ivoire, Mishra et al. reported a national prevalence of swine cysticercosis at 2.5%. Bouaké and Korhogo districts harbored the highest prevalence with 5.7% and 3.9% of infected pigs detected by visual inspection in slaughterhouse respectively (Mishra and N'depo, 1978). In 1991, Danho et al. reported a national prevalence of 3.6% (Danho, 1991). However between 2013 and 2014, out of 56,700 animals slaughtered, the Ministry of animal health reported only 151 cases of cysticercosis in pig carcasses collected at the Société Ivoirienne d'abattage et de Charcuterie (SIVAC) (Offianan et al., 2015) which confirmed that pig cysticercosis was still present in Côte d'Ivoire.

For human, some cases of neuro- and cutaneous cysticercosis have been reported by Heroin et al. (Heroin et al., 1972) and Giordano et al. (1976). Similarly, human taeniasis has been reported in some regions of Côte d'Ivoire with a prevalence of 11.1%; 5.4% and 2.5% in Toumodi, Divo and Abidjan respectively (Offianan et al., 2015).

Hence it was urgent to improve knowledge on the circulation of the parasite in these traditional farms in order to help to strengthen food security.

The objective of this study was to estimate the seroprevalence of swine cysticercosis in rural areas of southern Côte d'Ivoire to identify determinants of the disease. These areas provide most of the pork meat sold in Abidjan, the economic capital of the country, accounting nowadays for six million inhabitants. For this study we used ELISA and western blot (WB) detection of antibodies against cysticercosis.

2. Materials and methods

2.1. Type and setting of the study

A cross-sectional survey was conducted in three rural areas of the southern region of Côte d'Ivoire, i.e. the districts of Dabou, Agboville and Aboisso (Fig. 1). These localities were chosen as study sites according to the importance of their traditional pig farming and their role in supplying the city of Abidjan (the economic capital) with pork. The department of Dabou, is located to the East of Abidjan, extending between 5° 19′ North latitude and 4° 23′ West longitude over an area of about 2260 km^2. The vegetation is characterized by a dense forest. The climate is sub-equatorial with an annual rainfall of 2000 mm. The district of Agboville, is located between 5° 55′ 41″ North latitude and 4° 13′ 01″ West longitude, with a surface area of 12,000 km^2 and a vegetation characterized by a dense semi-deciduous humid forest. The average annual rainfall is about 1400 mm with a humid tropical climate (Nguekam, 1998). Aboisso is located in the south-east part of Côte d'Ivoire between longitude 2°40 and 3°40 West and latitude 5° and 6°20 North, 116 km from Abidjan and 60 km from the Ghana border. The department of Aboisso covers an area of 4662.17 km^2 with a very uneven relief, a hot and rainy climate of equatorial type and a vegetation characterized by dense forests.

2.2. The population of study

The population of study consisted of pigs selected from villages rearing herds of >10 pigs. It was planned to include 600 pigs to demonstrate an expected seroprevalence of 50%, with a precision of 7% at a risk of error α of 5% and a power of 90%. The number of pigs to be sampled per department was determined by the quota method using pig census data obtained during preliminary investigations conducted by the National Agency for Support to Rural Development (ANADER). This pig population census counted a total of 3663 pigs on the study sites with 2537 (69.3%) pigs in Agboville, 713 (19.4%) in Dabou and 413 (11.3%) in Aboisso. Thus, it was planned to include at least 243, 197 and 160 village pigs in Agboville, Dabou and Aboisso respectively, for a total of 600 pigs. After obtaining consent of the farmer to participate in the study, pigs at least 3 months old were selected. For each farm, one pig out of two was sampled until reaching the target number of animals per village.

2.3. Data collection

The data were collected using a questionnaire proposed to each breeder. It was related to the socio-demographic characteristics of the household (age, sex, seniority, level of education) and to the characteristics of the farm: system of breeding, type (traditional or modern) of breeding, feeding, water supply, veterinary care. In addition, direct observations were made on the environment of the barn (presence of latrine, level of hygiene). A 4 ml blood sample was taken from each animal included in the study using a dry tube. Information regarding the characteristics of each animal collected (age, weight, breed, type, health status and general health of the animal) was also collected. Weight was determined using a weighting hook. Animals were considered as lean for a weight under the weight-for-age average of the breed. Overweight was considered for animals with a weight 15% over the average and fat for weight 25% over the average.

2.4. Biological tests

Analyses were conducted using ELISA and Western Blot serological tests with glycosylated *T. solium* larva antigens as recommended (Ramahefarisoa et al., 2010). WB was used on ELISA positive samples only. ELISA is considered as a screening test with a sensitivity of 79% and a specificity of 75% in pigs as described in previous studies in Madagascar. Whereas WB was at higher specificity (>95%) (Ramahefarisoa et al., 2010; Tsang et al., 1989). The vesicular antigens were prepared at the Institut Pasteur Paris from ground cysticerci of *T. solium* collected in Madagascar from meats of lean pigs (collected in markets and in slaughterhouses). Membrane

glycoproteins of *T. solium* cysticerci were extracted and purified according to the method of Tsang et al. (Tsang et al., 1989).

The sera were collected after clotting and first analyzed by ELISA (IgG) according to the modified methods of Tsang et al. (Tsang et al., 1989) and Ramahefarisoa et al. (Ramahefarisoa et al., 2010). Although it doesn't correlate with living parasite carriage, it is useful to estimate circulation of the parasite (Gonzalez et al., 1990). IgG serum antibodies reacting with the parasite were revealed by a peroxydase labelled anti-pig antibody and chromogen substrate (chromogen). Optical density (OD) was determined with a spectrophotometer at 490 m wavelength. The positivity threshold corresponds to the mean optical density of a series of six negative samples, plus three standard deviation (detailed protocol is available on www.protocols.iso).

ELISA positive sera were secondly analyzed by western blot (IgG) according to Tsang et al. (Mirah/dpsp, 2017) modified by Gonzalez et al., Michelet and Ramahefarisoa et al. (Gonzalez et al., 1990; Michelet, 2010; Ramahefarisoa et al., 2010). This Western blot test with a sensitivity of 95% and a specificity of 100% uses the same antigens splitted according to molecular weight by electrophoresis on a polyacrimide gel (Gonzalez et al., 1990). The proteins are then transferred onto a nitrocellulose membrane. ELISA positive sera were then incubated with strips and detected in the same way with anti-IgG pig conjugated antibodies.

In our study, a sample was said to be positive to western blot, if it had at least two bands among: P6–8, P12, P23–26, P 39, P45 (Michelet, 2010), because a single band will not be specific enough to the pathogen (Michelet, 2010). The P50–55 band was not considered in this study as it is supposed to be cross-reactive with *Taenia hydatigena* (Muro et al., 2017).

2.5. Statistical analysis

Quantitative variables were described by their mean and standard deviation and qualitative variables by proportions. Dependent variables were, the presence of cysticercosis-infected pigs in the farms or cysticercosis positive serology for the pig. Analysis was conducted at the farm level considering presence/absence of infected pigs and percent of infected pig in the farm as variables. The determinants for the presence of cysticercosis-positive pigs in the farms and for seropositivity of the pigs were analyzed using logistic regression models. To do this, variables were first selected for the models by univariate analyses. Categorical variables were compared with the Chi^2 test or Fisher's exact test, if applicable, and quantitative variables with the Student's or Wilcoxon's test. Backward logistic regression models were constructed with variables associated with the dependent variables with a significance level of $p < 20\%$ during univariate analyses. The final models retained only the variables associated with the dependent variables at the 5% level in a two-sided formulation.

Data were entered from Epidata 3.1 software and Stata™ software, version 11, used for the analyses.

3. Results

3.1. Description of the study population

3.1.1. Characteristics of the pig farms

Out of the 124 farmers contacted between February 2017 and February 2018, 116 (93.5%) agreed to participate in the study. Indeed, 8 farmers refused to participate: 1 in Dabou; 2 in Aboisso and 5 in Agboville. The study revealed a predominance of males (82.8%) among the farmers, with a M/F sex ratio of 4.8. More than half of them (56%) were over 45 years old; 36.2% had not attended school and 85.3% had been farming for more than one year. Slightly more than half of the selected farms were located in the department of Agboville (51%). See Table 1.

In the department of Dabou, 33 farms were visited in 8 villages. The majority of the farms (33.3%) were located in the village of Cosrou. In Agboville, 59 pig farms were visited in 13 villages, with the majority in the village of Boka Oh'O. The number of farms varied from 1 to 12 in the villages. In the Department of Aboisso, farms were selected in 10 villages with a maximum of farms visited in the village of Bodjénou. The number of farms visited varied from 1 to 7. Cysticercosis-positive pigs was observed in 41.4% of the farms

Table 1
Socio-demographic characteristics of livestock farmers visited in the departments of Dabou, Aboisso and Agboville.

Variables	Items	Total N (%)
Sex	Male	96 (82.8)
	Female	20 (17.2)
Age group	From 18 to 45 years	51 (44.0)
	>45 years	65 (56.0)
Education level	None	42 (36.2)
	Primary school	39 (33.6)
	Secondary school	33 (28.5)
	Higher Education	02 (01.7)
Duration in the farm	<6 months	05 (4.3)
	Between 6 and 12 months	12 (10.3)
	>12 months	99 (85.4)
Farm location	Aboisso	24 (20.7)
	Agboville	59 (50.9)
	Dabou	28 (28.4)

visited (Fig. 1).

Among the 116 farms visited, 84.5% practiced traditional type husbandry with permanent straying in 62% of cases. The presence of a latrine and the notion of washing of the pigsty were reported respectively in 25.2% and 6.1% of the farms. Only 8.7% of farmers had declared disinfecting their farms. In addition, the majority of pigsties were located within 100 m of household waste dumps (88.7%) (Table 2).

Most of the farmers (96.5%) declared not using commercial foods to feed animals. Those who reported using commercial foods (3.5%) also declared using only locally-made products. 12.2% of breeders reported feeding their animals with homemade foods while 86.1% of them reported feeding their animals with household wastes (Table 2).

About animals watering, breeders mentioned several sources, i.e. borehole water (9.9%), wells (32.4%), running water (21.6%), watercourses (47.8%) or rainwater reservoirs (37.1%).

Among these farmers, 34,5% asserted to provide veterinary follow-up to their herds (Table 2).

They reported using antihelminthic drugs with mainly ivermectin or albendazole, antibiotics anti-inflammatory drugs and vitamins. The average size of the farms visited was 22 ± 41 pigs ranging from 1 to 300 pigs, (median number and interquartile range: 11 (5.5–20)). The herds were composed on average of 6 ± 7 sows (min = 0 and max = 50), 2 ± 3 boars (min = 0 and max = 20) and 7 ± 9 piglets (min = 0 and max = 41).

3.1.2. Characteristics of the pigs selected

The total number of pigs sampled was 668 with 208 (31.1%) in Dabou, 182 (27.3%) in Aboisso and 278 (41.6%) in Agboville. The majority of pigs sampled were of local breed (51.8%) and most often female (72.3%). Approximately one third of these animals were over 12 months old (37.3%) with a weight between 10 and 30 kg (32.8%). Most of the pigs (61.5%) were reproductive animals and half of them were overweight. 58.7% of the pigs harbored clinical signs of various diseases such as dermatosis.

An ELISA serology was carried out for 639 pigs among which 253 (39.6%) were positive. The Western blot technique was only used for the 243 ELISA positive sera to confirm the result due to the insufficiency of serum for 10 samples. Overall, 83 serums (13.2%, 10.6–15.8) were confirmed as seropositive for cysticercosis (Table 3).

Table 2
Characteristics of farms.

Parameters	Items	N	%
Type of breeding	Improved	18	15.5
	Traditional	98	84.5
Breeding mode	Permanent wandering	72	62
	Partial wandering	22	19
	Enclosure breeding	22	19
Presence of latrine	No	86	74.8
	Yes	29	25.2
Pigsty washing	No	107	93.9
	Yes	7	6.1
Pigsty disinfection	No	105	91.3
	Yes	10	8.7
Distance between landfill and farm	<10 m	91	79.1
	Between 10 and 100 m	11	9.6
	>100 m	13	11.3
Presence of drains	No	110	95.7
	Yes	5	4.3
Consumption of commercial food	No	111	96.5
	Yes	4	3.5
Consumption of farm-produced food	No	101	87.8
	Yes	14	12.2
Consumption of food from household waste	No	16	13.9
	Yes	99	86.1
Watering with borehole water	No	100	90.1
	Yes	11	9.9
Drinking with well water	No	75	67.6
	Yes	36	32.4
Drinking with running water	No	87	78.4
	Yes	24	21.6
Watering with streams	No	59	52.2
	Yes	54	47.8
Watering with rainwater running off	No	73	63
	Yes	43	37
Veterinary care	No	76	65.5
	Yes	40	34.5

Table 3
Characteristics of the pigs selected from the farms visited.

Variables	Items	N	(%)
Department	Aboisso	183	27.3
	Agboville	278	41.6
	Dabou	208	31.1
breed	Local	346	51.8
	Metis	304	45.5
	imported	18	2.7
Sex	Male	185	27.7
	Female	483	72.3
Animal age group	less 6 months	179	26.8
	between 6 and 12 months	240	35.9
	≥12 months	249	37.3
Animal weight	10 Kg	200	29.9
	Between 10 and 30Kg	219	32.8
	Between 30 and 70 Kg	183	27.4
	≥70 Kg	66	09.9
Animal type	Pig Breeder	411	61.5
	Piglet	209	31.3
	Pig butcher	38	05.7
	reformed pig	10	01.5
General condition of the Animal*	Lean	201	30.1
	Overweight	331	50.3
	Fat	131	19.6
Presence of clinical signs	No	276	41.3
	Yes	392	58.7
Presence of ectoparasites	No	114	33.0
	Yes	232	67.0
T solium serology	Negative	546	86.8
	Positive	83	13.2

(* lean: skinny animal; Overweight: high muscle level)

3.2. Determinant factors for positive cysticercosis serology

3.2.1. Factors associated with the presence of seropositive pigs in a farm

The univariate analyzes demonstrated a link between the presence of pigs seropositive for *T. solium* in the farm and the presence of latrines ($p = 0.034$). Overweight [OR = 2.6; 95% CI 1.3–4.9] and fat pigs [OR = 2.3; 95% CI 1.0–4.8] were twice as likely to be seropositive for cysticercosis. However, no statistically significant link was demonstrated with the type of breeding ($p = 0.064$), the breeding system practiced ($p = 0.055$), the notion of washing of the pigsty ($p = 0.123$), the distance between the places of defecation and the pigsty ($p = 0.061$) (Table 4).

In multivariate analysis, the presence of seropositive pigs in a farm was also associated with presence of wells [OR = 2.5 95% CI 1–6.31, p 0.049], the notion of veterinary care [2.99, 95% CI 1.22–7.31, p 0.016], and the number of pigs sampled by farm [OR = 1.23 95% CI 1.09–1.42, p 0.001].

3.2.2. Factors associated with positive serology for a pig

In univariate analysis, positive serology (Cysti +) in pig was associated with the mixed breed ($p = 0.020$), an older age ($p = 0.042$), a high weight ($p = 0.025$), its general condition ($p = 0.010$), the absence of clinical signs ($p = 0.008$) and the place (district) of location of the farm ($p = 0.000$). (Table 5).

In multivariate analysis, compared with lean pigs, overweighted pigs and fat ones had more often a positive serology [OR = 2.6 95% CI 1.4–4.9, p 0.003; 2.3 95% CI 1.1–4.9, p 0027, respectively].

4. Discussion

This serological survey conducted in rural areas commercially connected to Abidjan, had the objective to estimate circulation of *T. solium* in herds. An estimated prevalence of 13.2% [95% CI 10.57, 15.82] was found over the three districts. However, this prevalence greatly varied from a district to another with the highest proportion (20.74%) in Dabou. In this district, positive serologies were reported in all villages with a minimum prevalence of 9% in Ndoumikro and a maximum of 35.7% in Viel aklodj. Taking into account the short duration of rearing and Although the fact that the majority of the farms investigated were conducted in enclosures, these results confirmed a high level of circulation of the parasite in Dabou district.

Several factors can explain this level of exposure. Indeed, these animals would not receive veterinary care appropriately. Rearing of pigs in Dabou is an historical tradition. The town of Dabou was an important regional capital. In the 19th century, with the construction of Fort Faidherbe, it became a very important administrative and socioeconomic center. The production of palm oil encouraged immigration of Bambara, Senegalese, Ghanaian, Apollonian, European and even Ivorian traders from other departments

Table 4
Characteristics of farms according to the presence of seropositive pigs in the farm.

Parameters	Items	No	Seropositive pigs		%	P[1]
			%	Yes		
Type of breed	mestizo	7(41.1)	10,3	61(62.2)	89,7	0.06 [2]
	local African	11(64.7)	22,9	37(37.7)	77,1	
Husbandry mode	Permanent wandering	47(69.1)	65,3	25(52.1)	34,7	
	Partial wandering	13(19.1)	59,1	9(18.8)	40,9	0.055 [2]
	Enclosure husbandry	8(11.8)	36,4	14(29.2)	63,6	
Presence of latrine	No	46(67.7)	53,5	40(85.1)	46,5	0.034 [2]
	Yes	22(32.3)	75,9	7(14.9)	24,1	
Pigsty washing	N	65(97.0)	60,7	42(89.4)	39,3	0.12 [2]
	Yes	02(3.0)	28,6	05 (10.6)	71,4	
Pigsty disinfection	No	62(91.2)	59,0	43(91.5)	41,0	1.000
	Yes	06(08.8)	60,0	04(08.5)	40,0	
Distance between landfill and farm	less 10 m	58(85.3)	63,7	33(70.2)	36,3	0.085[2]
	between 10 and 100 m	06(08.8)	54,5	05(10.6)	45,5	
	>100 m	04(5.9)	30,8	09(19.2)	69,2	
Presence of drains	No	66(97.1)	60,0	44(93.6)	40,0	0.398
	Yes	02(02.9)	40,0	03(06.4)	60,0	
Consumption of commercial food	No	65 (97.0)	58,6	46(95.8)	41,4	1.000
	Yes	02(03.0)	50,0	02(04.2)	50,0	
Consumption of farm-produced food	No	63(94.0)	62,4	38(79.2)	37,6	0.016 [2]
	Yes	04 (06.0)	28,6	10(20.8)	71,4	
Consumption of food from household waste	No	08(11.9)	50,0	08(16.8)	50,0	0.470
	Yes	59(88.1)	59,6	40(83.3)	40,4	
Watering with borehole water	No	58(90.6)	58,0	42(89.4)	42,0	1.000
	Yes	06(9.4)	54,5	05(10.6)	45,5	
Drinking with well water	No	49(76.5)	65,3	26(55.3)	34,7	0.018 [2]
	Yes	15(23.4)	41,7	21(44.7)	58,3	
Drinking with running water	No	50(78.1)	57,5	37(78.7)	42,5	0.940
	Yes	14(21.9)	58,3	10(21.3)	41,7	
Watering with streams	No	31(47.0)	52,5	28(59.6)	47,5	0.186 [2]
	Yes	35(53.0)	64,8	19(40.4)	35,2	
Watering with rainwater running off	No	38(55.9)	52,1	35(72.9)	47,9	0.061 [2]
	Yes	30(44.1)	69,8	13(27.1)	30,2	
Veterinary care	No	52(68.4)	10,3	24(31.6)	89,7	0.003 [2]
	Yes	16(40)	22,9	24(60.0)	77,1	
number of pigs selected / farm (m ± ET)		4.6 ± 0.3		7.4 ± 0.7		0.0001 [2]

(1 Fisher's exact test; [2] Variables selected for the multivariate model).

(Lasme and Kouassi, 2018). This trade should have enhanced imports of various microorganisms including *T. solium* in this area. In the same line, Dabou is closer to Abidjan (the economic capital) than the other areas. Commercial and administrative exchanges with this capital are intense, and a high concentration of pig farms.

Positive serologies were reported in 70% and 38.5% of villages around Aboisso and Agboville respectively. However, the global prevalence of positive pigs was lower in these two-area compared with Dabou. As suggested by the multivariate analysis, prevalence variations could be related to practices and environment of the farms.

Among the 116 farms visited, 84.5% harbored at least one infected pig which highlights a large spread of the disease over these districts. The general practice of husbandry was the traditional permanent straying as in most of African villages. In the same way as in other West African rural areas the local breed was the most present, compared to the mestizo and exotic breeds (Missohou et al., 2001; Secka et al., 2010). In Central and West Africa, authors reported that the traditional system was mainly practiced in peasant areas and in forests (Agbokounou et al., 2016). In Burkina Faso, traditional village pig husbandry represented up to 90% of the national herd (FAO, 2012).

This study highlighted factors associated with positive serology for cysticercosis, linked to practices of breeders. Seropositive pigs were more often detected in the farms where breeders declared providing them with well water, and especially when husbandry are located <100 m from household landfills usually used for open defecation. These wells are only for the water supply of the livestock and they are not used for human consumption but well water can thus be contaminated by human excreta. This contamination could also arise from runoff, sewage or sewage water that would carry the eggs of parasites present in the environment into these wells. These herds fed by well water were mostly in enclosures and therefore benefited from the same water sources increasing risk of infection (Agbokounou et al., 2016). This study also showed that mixed breed pigs were more often seropositive compared to other breeds. However, similar studies conducted in slaughterhouses from Madagascar showed the opposite results (Clément, 2016) suggesting that the different husbandry conditions and especially water supply would be a more important factor in the contamination. In the same line, in this study, older pigs (and in the same way fatter ones) had a higher seroprevalence than younger ones in univariate analysis but not in multivariate model. This is in accordance with authors in Africa (Nguekam, 1998; Pondja et al., 2010) but not in South America (Mopate et al., 2009; Sarti et al., 1992). The higher the age of slaughter, the more likely it is that the animals will be infected by

Table 5
Factors associated with positive serology in pigs.

Parameters	Items	Cysti -		Cysti+		p
		N (%)	%tot	N (%)	%tot	
	Local	292(53.5)	89,3	35(42.2)	10,7	
	Metis	237(43.4)	83,2	48(57.8)	16,8	0.020[1]
breed	imported	17(03.1)	100,0	00(00.0)	0,0	
Animal age group	<6 months	156(28.6)	91,8	14(16.9)	8,2	0.042 [1]
	[6 to 12 months]	192(35.2)	86,9	29(34.9)	13,1	
	> 12 months	198(36.3)	83,2	40(48.2)	16,8	
Sex	Male	158(28.9)	89,3	19(22.9)	10,7	0.254
	Female	388(71.1)	85,8	64(77.1)	14,2	
	<10 Kg	175(32.1)	92,1	15(18.1)	7,9	0.025 [1]
	Between 10 and 30 Kg	179(32.8)	87,3	26(31.3)	12,7	
	Between 30 and 70 Kg	142(26.0)	82,1	31(37.4)	17,9	
Animal weight	>70 Kg	50(09.2)	82,0	11(13.2)	18,0	
	Pig Breeder	327(59.9)	84,1	62(74.7)	15,9	0.051 [1]
	Piglet	176(32.2)	90,3	19(22.9)	9,7	
	Pig butcher	34(06.2)	94,4	02(02.4)	5,6	
Animal type	reformed pig	09(01.7)	100,0	00(00.0)	0,0	
	Lean	174(31.9)	93,0	13(15.7)	7,0	0.010 [1]
	Overweight	262(48.0)	83,7	51(61.4)	16,3	
Aspect	Fat	110(20.1)	85,3	19(22.9)	14,7	
	No	206(37.4)	82,4	44(53.0)	17,6	0.008 [1]
Clinical signs	Yes	340(62.3)	89,7	39(47.0)	10,3	
	Aboisso	152(86.9)	86,9	23(13.1)	13,1	0.000 [1]
	Agboville	245(92.1)	92,1	21(07.9)	7,9	
Site of the farm	Dabou	149(79.3)	79,3	39(20.7)	20,7	

Fisher's exact test; [1] Variables selected for the multivariate analysis.

T. solium. Overall, these results support that, ultimately, husbandry condition is the main factor of contamination and especially the water supply.

A surprising link was found between positive serology for cysticercosis and veterinary care reported by the farmers. This can be due to a poor knowledge on antiparasitic protocols or on false declaration by farmers aware of the poor sanitary state of their herds. In the opposite way, other breeders in rural areas did not even conceive that a pig could be sick. Indeed, some authors have shown that the majority of breeders in rural areas did not care for their animals. Veterinary cares seem only practiced by farmers who practice improved breeding (European, American or Metis breeds in enclosure) (Youssao et al., 2008). The use of veterinary care seems to be more frequent in urban areas (Youssao et al., 2008).

Overall the presence of the parasite seems also be due to the lack of control of tapeworms and of human cysticercosis in these regions which could be related to the poverty of the people living in these rural areas and also to a poor health education (Sciutto et al., 2000).

5. Conclusion

Controlling cysticercosis in pigs is very important to prevent the spread of infection. Older and fatty animals, consuming well water and breed closed to the household were the most infected animals. It is thus important to educate the population on breeding practices. Pigs should be confined in pens or in a site from where they do not have access to human feces. They should receive adequate foods, water and veterinary care. The population should be sensitized to hygienic practices such as the construction of latrines away from enclosures of breeding animals in order to prevent the spread of parasite eggs into the environment.

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Author contributions

Conceptualization, SKM, MB, RJ; methodology, SKM, MB, RJ, OMB; validation, SMK, RJ; formal analysis KEK, KBD, CM, JM.; investigation, KEK, OMB; resources, JB, MN; data curation, SMK, KEK; writingoriginal draft preparation, KEK, SMK, RJ; writingreview and editing, KEN, AOT; visualization, X.X.; supervision, JD, KEN, OAT, RJ; project administration, SMK, RJ; funding acquisition, RJ. All authors have read and agreed to the published version of the manuscript.

Ethics approval and consent to participate

The study was approved for the human aspects by the National Ethic Committee, and by an internal ad hoc committee including members of the livestock minister, for the animal aspects. Villagers gave their informed consent to participate.

Consent for publication

All the authors read the final text and agreed to submit the manuscript in its present form.

Declaration of Competing Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Data availability

Data are covered by administrative approval. They can be obtained from the authors through reasonable requests.

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